

AD-A207 015

AIRCRAFT SUSTAINABILITY MODEL
VERSION 1.5: USERS MANUAL

Report AF801R2

March 1989

Frank L. Eichorn

DTIC
ELECTE
APR 20 1989
S H D

Prepared pursuant to Department of Defense Contract MDA903-85-C-0139.
The views expressed here are those of the Logistics Management Institute at
the time of issue but not necessarily those of the Department of Defense.
Permission to quote or reproduce any part must - except for Government
purposes - be obtained from the Logistics Management Institute.

LOGISTICS MANAGEMENT INSTITUTE
6400 Goldsboro Road
Bethesda, Maryland 20817-5886

089 4 20 002

CLASSIFICATION	EXEMPT A
REMARKS	public release;
	unlimited

Summary

AIRCRAFT SUSTAINABILITY MODEL VERSION 1.5: USERS MANUAL

The Aircraft Sustainability Model (ASM) is an item-specific inventory model that relates investments for spares to aircraft sortie generation capability during a conflict. An important advantage of the ASM is its ability to produce an entire curve relating a wide range of investment levels to the resulting sortie generation capability, allowing Air Force planners to trade off spares investment and capability. Moreover, the algorithm that builds the curve explicitly trades off investment in line replaceable units installed directly on aircraft versus their constituent shop replaceable unit subassemblies. These features, together with the computational efficiency of the code, have led to rapid acceptance of the ASM within the Air Force Logistics Command (AFLC). AFLC is now incorporating the ASM into the Requirements Execution Availability Logistics Module (REALM) of the Weapon System Management Information System (WSMIS). The ASM is being used in WSMIS/REALM to compute item requirements and to execute the Air Force budget for the reparable spares portion of War Reserve Materiel (WRM).

This users manual explains the use of the ASM Version 1.5. This manual should be helpful to all Air Force logistics analysts with access to the ASM who are responsible for spares requirements or spares policy. It describes model inputs and provides sample executions. While this document is intended primarily for the users of the personal computer version of the ASM, it nonetheless describes the core of the computational algorithms now being installed into the WSMIS/REALM production system.

Development of the ASM continues. Work in progress includes techniques for optimizing over time, for increasing cannibalization options, and for enhancing treatment of depot support. Air Force WRM policy has been influenced by the limitations of existing software. We believe the new capabilities afforded by the ASM will lead to a re-examination of these policies. The setting of minimum "floor" quantities for each item and the definition of performance objectives now being used

to determine spares requirements are candidates for re-evaluation. The possible impact of the ASM upon Air Force policy will be the subject of future LMI reports.

CONTENTS

	<u>Page</u>
Executive Summary	iii
Chapter 1. Overview	1- 1
Introduction	1- 1
Computer Requirements and Installation	1- 2
Model Structure	1- 3
Chapter 2. The Converter	2- 1
Overview	2- 1
Detailed Instructions	2- 1
Chapter 3. Aircraft Sustainability Model	3- 1
ASM Runtime Parameters – PARAMS	3- 1
ASM Run	3- 9
Curve	3-10
ASM Outputs	3-16
Chapter 4. Shopping Lists	4- 1
LISTSHOP	4- 1
EVALSHOP	4- 2
Chapter 5. LISTPART	5- 1
References	Ref. 1
Appendix A. Aircraft Sustainability Model File Formats	A-1 – A-7
Appendix B. Comparison of the Aircraft Sustainability Model 1.5 and Dyna-METRIC 4.4	B-1 – B-4, r

[illegible]

CHAPTER 1

OVERVIEW

INTRODUCTION

The Aircraft Sustainability Model (ASM), developed for the Air Force, relates investment in War Reserve Materiel (WRM) spares to fighting ability over time. Specifically, it relates spares funding to a confidence level, expressed as a *probability*, that the aircraft will sustain the flying levels specified in the Air Force War and Mobilization Plan (WMP). The ASM is computationally efficient: it is capable of analyzing in a few minutes the best mix of spares (from hundreds of components) that will achieve the required operational objective. This objective, as dictated by Air Force policy, is the acceptable percentage of aircraft that may be grounded on a particular day of the combat scenario. This model enables military planners to develop and evaluate budgets for WRM in a way that is rational and defensible.

The ASM is the product of more than 20 years of research within the Air Force community. The underlying mathematics – computations of resupply pipelines, confidence levels, etc. – are entirely consistent with Dyna-METRIC 4.4¹ (hereafter referred to as DM) [1]. The ASM is component-specific, multi-echelon (two levels of supply – bases and depots), and multi-indenture: it distinguishes between line replaceable units (LRUs) installed directly on aircraft and their shop replaceable unit (SRU) subassemblies.

The ASM uses component-specific data, including item failure rates, resupply times, etc., that are consistent with DM. In fact, CONVERTER preprocessing software reads a DM 4.4 input deck [2] and creates data files suitable for ASM input. Use of the CONVERTER program is described in Chapter 2 and the ASM data file formats are defined in Appendix A of this report.

While DM is capable of computing requirements, it is used throughout the Air Force primarily as an *assessment* tool. The ASM computes requirements better.

¹Dyna-METRIC = Dynamic Multi-Echelon Technique for Recoverable Item Control, a model developed by The RAND Corporation.

Specifically, the ASM is able to optimally tradeoff both the value of sparing LRUs versus SRUs and their locations in base or depot stocks. The ASM architecture has been borrowed largely from the LMI Aircraft Availability Model (AAM) [3], a large-scale model now being implemented by the Air Force Logistics Command (AFLC) to relate *peacetime* spares to aircraft readiness. The ASM processes each spare component one at a time in such a way to produce an entire *curve* that relates total cost to performance. This feature provides the analyst with increased credibility to defend budgetary requirements and the ability to achieve the greatest readiness capability with limited funding.

These attributes have led to rapid acceptance of the ASM within the Air Force. It has been incorporated into the Requirements Execution and Availability Logistics Module (REALM) of the Weapon System Management Information System (WSMIS) to determine the requirements for War Readiness Spares Kits (WRSKs).

This manual describes the steps required to run the personal computer (PC) version of the ASM. It covers installation procedures, data input formats, step-by-step instructions for each module, and sample outputs. Technical detail concerning the underlying mathematics of the ASM can be found in References [4] and [5].

COMPUTER REQUIREMENTS AND INSTALLATION

An IBM AT or compatible microcomputer with Disk Operating System (DOS) 3.1 or higher, an Intel 80287 or 80387 math coprocessor, and a hard disk drive are required. The ASM software is normally shipped on 1.2 megabyte (Mb) diskettes. Installation of the ASM on a hard disk requires approximately 2.5 Mb of storage. The source diskette requires another 1.2 Mb, but it is not necessary for ASM operation. At least 1 Mb of free storage must be available for ASM output files.

The ASM code is written in FORTRAN-77 and has been compiled with the Lahey compiler. The source code is included in the ASM distribution packet and has been designed for transportability to other systems. For example, the WSMIS/REALM version used in the AFLC Honeywell batch environment is the same as the PC version except for minor input/output and user interface instructions.

Each of the ASM diskettes contains an installation program that, when run, will load that diskette onto a hard disk. In addition, the user must include the commands "FILES=20" and "DEVICE=ANSI.SYS" in the CONFIG.SYS file.

The installation program builds the directory structure shown in Table 1-1.

TABLE 1-1
DIRECTORY STRUCTURE

Directory	Description
\\ASM	All BAT and EXE files, as well as sort command files
\\ASM\\DATA	DM 4.4 and ASM input data
\\ASM\\SOURCE	All ASM source programs (FORTRAN-77)
\\ASM\\OUTPUT	All intermediate and final ASM output data files

The model allows the user to change the default directories for input and output files. This is particularly useful for the user who wishes to perform multiple ASM executions without overwriting the results.

MODEL STRUCTURE

The ASM is divided into different functional modules. Each module is executed by typing the module name, as indicated in Table 1-2.

TABLE 1-2
ASM FUNCTIONAL MODULES

Module name	Chapter	Description
CONVERT	2	Converts a DM 4.4 data deck into ASM format.
ASM	3	Core module: processes all SRUs, then LRUs. Produces a curve showing confidence against cost. Allows the user to select a particular point on the curve for generation of a component buy list.
LISTSHOP	4	For the decision point selected on the curve, LISTSHOP produces the optimal item buy list of LRUs and SRUs. The exact cost of the total buy is computed.
EVALSHOP	4	Evaluates a buy list produced by LISTSHOP. Computes the exact confidence level, as well as expected number of grounded aircraft, and total LRU backorders.
LISTPART	5	Produces a list of marginal buys in descending order of benefit per dollar.

Chapters 2 through 5 of this manual address each module in detail, providing both the procedures for executing the model and the descriptions of sample outputs.

CHAPTER 2

THE CONVERTER

OVERVIEW

The CONVERTER is a preprocessor that reads a DM 4.4 input deck and creates ASM input files. (See Appendix E of Reference [2] for documentation.) The underlying algorithms of DM and the ASM are virtually identical. The two models produce comparable assessments, but the ASM is superior for generating spares *requirements*.

The ASM architecture is very different from DM. The ASM achieves its speed and efficiency by processing each component only once, computing the value of each possible investment. The CONVERTER module first consolidates the information about a single component that is usually scattered throughout a DM deck. This consolidation eliminates the extensive core required for DM. The file formats for the corresponding component data files (one file for SRUs and another for LRUs) are included in Appendix A.

During processing, the CONVERTER may encounter data record types for which the ASM has no corresponding feature. (In most of these cases, ASM processing corresponds to the default values used in DM if these cards were not present.) In any case, the CONVERTER displays a message indicating the presence of these DM records and stating how they will be handled. Appendix B contains a more detailed comparison of the capabilities of the ASM and DM, and describes those features available in DM that are not supported by the ASM.

DETAILED INSTRUCTIONS

To run the CONVERTER, the user should be in the ASM directory, if installed using the INSTALL.BAT program. Enter "CONVERT" at the DOS prompt. After the banner screen has been displayed, the program will request the name of the file to be converted.

Enter the name of the Dynametric input file.
If the file is not in your current working
directory, enter the complete path name.
==>

Example Response: \ASM\DATA\F111DYNA

The DM-formatted file may reside in any directory on any drive. If the file is on a different drive, the drive specifier must be included in the path name (for example, A: DMDECK).

Next, the prompt for a kit identifier appears. This can be any label you choose to identify the kit. Thirteen characters are allowed so you may use an Air Force WRSK serial number if appropriate.

Enter the kit designator or any descriptive name
you want to associate with this kit (up to 13
characters).
==>

Example Response: 0F111D0D1800

The next prompt allows you to direct the CONVERTER output files (ASM input files) to a different directory.

The default directory for CONVERTER output is \ASM\DATA. The files created by the CONVERTER are used as input to the ASM. If you want them stored in a different directory, enter that directory name here. (30 characters max., <CR> for default.)
Ex. C:\USER\DATA
==>

Example Response: <CR>

The default file name prefix of ASM should be changed for data files that you want to keep for more than one run.

The CONVERTER creates four files for ASM input.

ASM.PRM	-	Model Run Parameters
ASM.SC	-	Flying Hour Scenario
ASM.1	-	LRU Component Data
ASM.2	-	SRU Component Data

Note that these files all have the same prefix with a different extension. If you would like a prefix other than ASM enter it here.
==>

Example Response: F111

If you used the example responses shown for the last two prompts, the CONVERTER would create four files – F111.PRM, F111.SC, F111.1, F111.2 – in the \ASM\DATA directory. The CONVERTER also places an exact copy of the parameter file in the \ASM directory and names it PARAMS. This is the file that the ASM reads for model initialization. It contains the flying-hour scenario, model parameters (as discussed in Chapter 3), and the file name prefix (F111 in the above screen) corresponding to the component data files.

During processing, the day of analysis and the total flying hours through that day are displayed. Note that the ASM only processes a single day at a time. Therefore, the CONVERTER reads the largest day indicated in the DM deck and

writes that to the parameter file. However, this can easily be changed when running the ASM. (See Chapter 3.)

When processing is complete, the CONVERTER will display a finished message.

```
*** DynaMETRIC Data Conversion Complete ***"  
-----"  
The PARAMS file contains the runtime"  
options found in this deck. To run"  
the model enter 'ASM'."
```

You are now ready to run the ASM module as described in Chapter 3. The complete file formats for the ASM input files, as created by the CONVERTER, are included in Appendix A.

CHAPTER 3

AIRCRAFT SUSTAINABILITY MODEL

Once data files are created, the ASM is ready to run. As discussed earlier, the ASM initially looks for a file named PARAMS in the ASM directory. This file is a copy of the *prefix.PRM* file created by the CONVERTER. If the file is found, the parameters are displayed and processing begins as described in the section titled "ASM Run" (page 3-9). However, if the ASM does not locate a PARAMS file, it will prompt you in detail for all the items and create one.

ASM RUNTIME PARAMETERS - PARAMS

To begin the model from within the ASM directory, enter "ASM". A banner screen will be displayed. After pressing the RETURN key (<CR>) to continue, the ASM reads the PARAMS file (if found) and displays its current settings.

```

                                ASM PARAMETER SETTINGS
Analyzing day                  : 30
ASM INPUT data directory      : \ASM\DATA\
ASM OUTPUT data directory     : \ASM\OUTPUT\
ASM Debug Option: NONE       Write Pipeline Files: T           Test Option: F
NSN Debug File   : NONE                               Use NEGLV as Stock Floor: F
Exponential: T      Fast Option: F      Peak Pipeline: F      Computer: PC
VMR Method(CONSTANT,AFLC,SHERBROOKE,VARI-1,2,3,4): 1  VMR Value: 1.0
Sacrosanct LRU Buys : 0.0                      Sacrosanct SRU Buys: 0.0
Weapon System Name  : F11A                      # of AC: 18 # of Bases: 1
Base Repair Begins - RR LRUs: 31   RRR LRUs: 3   SRUs: 31
Depot Repair Begins - RR LRUs: 999  RRR LRUs: 999  SRUs: 999
Day Order and Ship Starts : 0
Direct Support Objective  : 5.0   Component Data Name: F111
Component Data Array Limit : 1    # of Warning Days : 0
Comment: Sample DM4.4 deck for F111 WRSK
Enter Y if you would like to edit the flying hour Scenario file: N
                                ***PRESS ESC TWICE TO PROCEED***
```

You may modify the parameters by moving the cursor to an item and changing it. Descriptions of each item are obtained by pressing the F1 key twice (HELP). Note the last item on the screen regarding editing the flying-hour scenario. Enter a

"Y" here if you want to change the daily flying hours before proceeding to the model. Press the ESC key twice and the scenario data screen will be displayed.

SCENARIO FILE DATA

Last day flying hours change as indicated below: 8
Note: You only have to fill the flying hour array up to the last day that flying hours change. The model will assume that they will remain constant after that day.

FLYING HOUR PROGRAM

Day 0: 0.0	Day 1: 55.8	Day 2: 55.8	Day 3: 55.8	Day 4: 55.8
Day 5: 55.8	Day 6: 55.8	Day 7: 55.8	Day 8: 28.8	Day 9:
Day 10:	Day 11:	Day 12:	Day 13:	Day 14:
Day 15:	Day 16:	Day 17:	Day 18:	Day 19:
Day 20:	Day 21:	Day 22:	Day 23:	Day 24:
Day 25:	Day 26:	Day 27:	Day 28:	Day 29:
Day 30:	Day 31:	Day 32:	Day 33:	Day 34:
Day 35:	Day 36:	Day 37:	Day 38:	Day 39:
Day 40:	Day 41:	Day 42:	Day 43:	Day 44:
Day 45:	Day 46:	Day 47:	Day 48:	Day 49:
Day 50:	Day 51:	Day 52:	Day 53:	Day 54:
Day 55:	Day 56:	Day 57:	Day 58:	Day 59:

PRESS ESC TWICE TO PROCEED

After making changes on this screen, press the ESC key twice again. The ASM will begin processing as described in the section titled "ASM RUN" (page 3-9).

If a PARAMS file was not found, the ASM will prompt you for each item.

The first prompt requests the name of the directory where the input data files are located. The answer may include a drive designation if the files are located on a different drive (for example, A:\ASM\DATA).

The directory for ASM input data is set to:
 \ASM\DATA\

If your input data is in another directory, enter that directory name here or <CR> to leave as is.
==>

Example Response: <CR>

You then indicate where the ASM output files should be written. If you want to save the output files to a directory where they will not be overwritten during normal ASM processing, change this parameter (for example, \ASM\OUTPUT\EF111A\). To use the indicated default directory, just press <CR>.

The default directory for ASM output is:
 \ASM\OUTPUT\
If your input data is in another directory,
enter the directory name here or <CR> to use
the default.

==>

Example Response: <CR>

The next two items relate to the variance-to-mean ratio (VMR) processing options. The model supports four different techniques for computing VMRs: CONSTANT, which indicates that the VMR is constant for all components; AFLC or SHERBROOKE, where the VMR is set as a function of the pipeline mean;¹ or VARI, where the pipeline VMR is explicitly computed using the VARI-METRIC technique developed by Slay [6].

Variance-to-Mean (VMR) Ratio Options

The available VMR's are CONSTANT, AFLC, SHERBROOKE, and VARI. Select a new option or <CR> to use CONSTANT VMR
==>

Example Response: <CR>

You have selected the CONSTANT VMR

¹Subroutine VMCOMP contains the formulas for either the SHERBROOKE or AFLC VMR options.

You must then enter a VMR ratio to be used. A VMR of 1.0 (the default) assumes Poisson demand distributions.

Enter the variance to mean ratio, or
enter <CR> to use the default value of 1.0 ==>

Example Response: <CR>

At this point in the interactive sequence, the ASM gives you the opportunity to "redo" a series of questions.

You must then decide if you want the component quantity in the NEGLV (negotiated level) field (see Appendix A) of the component files to be purchased without regard to marginal benefit.

Do you want to use NEGLV as a stock floor?
Enter "Y" to use the floor, or enter <CR> to
use the default, no - floor ==>

Example Response: <CR>

As a processing option, the ASM supports the use of deterministic (fixed) or exponential resupply times. To conform to normal Air Force processing, exponential has been chosen as the default.

Do you want to use deterministic resupply?
Enter "D" for deterministic resupply, or enter
<CR> to use the default - exponential resupply ==>

Example Response: <CR>

The next items required are the days that repair is first available for different types of components. Here, the defaults represent the more commonly used options when analyzing day 30.

Enter first day of repair for RR LRUS, or
enter <CR> to use default - no RR LRU repair ==>

Example Response: 31

Enter first day of repair for RRR LRUS, or
enter <CR> to use default - RRR repair begins on day 1 ==>

Example Response: 3

Enter first day of repair for SRUS, or
enter <CR> to use default - no SRU repair ==>

Example Response: 32

You are again given the opportunity to change your responses.

The ASM then requests the name of the file that contains the flying-hour scenario. Since you have already entered the directory for the input files, you must only enter the file name here. The format for the scenario file is contained in Appendix A.

Enter the name, INCLUDING THE FILE EXTENSION,
for the file containing the WMP scenario ==>

Example Response: F111.SC

Next, are the number of units and number of bases supported by the WRSK. However, even though the ASM can process multiple bases, it assumes that they have identical repair times, shipping times, etc.

Enter the number of units of "0F111D0D1800"
deployed ==>

Example Response: 18

Enter the number of bases ==>

Example Response: 1

The next prompt is for the file name prefix of the component data files. This is the prefix you selected when building the files.

Enter the name of the component data files
the level 1 & level 2 files will use this name with
the extensions of ".1" & ".2" or enter <CR> to use
the default name "ASM" (in that case, the file
names would be "ASM.1" & "ASM.2" ==>

Example Response: F111

You then indicate the day of the wartime scenario that should be analyzed for this run.

Enter the day of the scenario to be analyzed ==>

Example Response: 30

Next, you must decide whether the model should purchase a percentage of the pipeline.

Enter the fraction of the pipeline which is to be bought, or enter <CR> to use the default value of 0 which buys no pipeline floor ==>

Example Response: <CR>

Current Air Force policy for computing WRSK calls for 100 percent pipeline as a "floor" requirement. If you instruct the model to purchase the pipeline (or a percentage of it), you constrain its capability to determine an optimum mix of components. This is mainly because the pipeline policy is somewhat inconsistent with the maximum cannibalization assumptions that are also part of Air Force WRSK policy. As a further explanation, consider the following simplified example: assume that the target number of grounded aircraft [not mission capable for supply (NMCS)] you entered is 6 and a particular component pipeline is computed to be 2 (at the end of a 30-day scenario). Assuming cannibalization, the ASM would compute

little or no requirement because the 6 NMCS aircraft would provide enough spares (pipeline of 2 plus 4 for safety level) to satisfy the demands for that component. But, if you instruct it to purchase the pipeline, it will buy at least 2 spares, making the kit more expensive than necessary.

If you do, however, choose to purchase the pipeline, you may also instruct the ASM to purchase the "peak" pipeline; i.e., the maximum value of the pipeline over the entire scenario (days 1 through 30 is the example).

Do you want the ASM to purchase the peak pipeline over the whole scenario. Enter Y if you want to process this way or N<CR> if you want to process normally.
==>

Example Response: <CR>

Then enter the target number of NMCS aircraft defined by Air Force policy as the direct support objective (DSO) for this run.

Enter the DSO -- the number of NMCS A/C permitted ==>

Example Response: 5.0

The last prompt is for a comment or title for this run. This will be written to the PARAMS file and a description is useful to identify the characteristics used for this particular run.

Enter any one line of comments regarding this
model run, or enter <CR> for no comment
==>

Example Response: F111 DEMO

The parameters will then be displayed as shown on page 3-1. After pressing the ESC key twice, the ASM begins execution, as described in the following section.

ASM RUN

The ASM begins by indicating that SRU processing has started and redisplay some key parameters being used for the run.

While processing, the ASM indicates its progress by printing a message after every 50 components. After SRUs are finished, some work files are sorted and then LRU processing begins. The display for LRUs is identical to SRUs, including the progress messages. After completion of LRU processing, the model has computed pipeline and marginal benefit information for all components and has stored this data in files in the output directory. The model will generate the cost versus availability curve next.

```

*****
**
**      ASMS NOW RUNNING FOR PROCESSING BY SUBASSEMBLIES (SRUs)      **
**
*****

PARAMETER SETTINGS FOR ASM RUN:

SAMPLE DYNA-METRIC 4.4 DECK FOR F111 WRSK
ANALYZING DAY          30
USING EXPONENTIAL RESUPPLY TIMES
FIXED VARIANCE-TO-MEAN RATIO OF      1.00000      USED FOR ALL COMPONENTS
PROPORTION OF PIPELINE FLOOR BOUGHT SACROSANCT=      0.00000
WEAPON SYSTEM NAME=0F111D0D1800
# OF A/C SUPPORTED=          18 AT EACH OF          1 BASES
DSO=      5.00000
RR LRU REPAIR STARTS ON DAYS 31 at BASE and 999 at DEPOT
RRR LRU REPAIR STARTS ON DAYS  3 at BASE and 999 at DEPOT
SRU REPAIR STARTS ON DAY      31 at BASE and 999 at DEPOT
ORDER & SHIP STARTS ON DAY      0
FLYING HOUR PROGRAM FOR ALL BASES, STARTING WITH DAY 0:
    0.00000      55.8000      55.8000      55.8000      55.8000
    55.8000      55.8000      55.8000      28.8000
WITH THE LAST VALUE SUSTAINED FOR THE REMAINING DAYS
*****END OF PARAMETER ECHO*****

NO. OF NSNS PROCESSED=      50 NSNIN=5841010713794
NO. OF NSNS PROCESSED=     100 NSNIN=5841011834307BJ
NO. OF NSNS PROCESSED=     150 NSNIN=5865010489979EW
NO. OF NSNS PROCESSED=     200 NSNIN=5999010722722BJ
NO. OF NSNS PROCESSED=     250 NSNIN=6605008909147BJ

# OF COMPONENTS PROCESSED 296 # WITH A REQ=      296
NSN'S TO RESULTS FILE 296 RESULTS FILE RECORDS      820
525 RECORDS WRITTEN TO UNSORTED 230
NPROCESS= 296 NSREADS=      0
MEBO,MSV=      35      1

LEVEL 2 ANALYSIS COMPLETE.
NO. OF COMPONENTS PROCESSED= 296 NO. WITH POTENTIAL EXPENDITURES= 296
*****
**
**      ASMS RUN COMPLETE. NOW SORTING SRU OUTPUT RECORDS.      **
**
*****

```

CURVE

This part of the model generates a cost versus aircraft availability table and if the user's machine has graphics capability, a graphed curve of the table. Because of the concept of the table, it is referred to as the "curve" throughout this document.

First the ASM will prompt the user to confirm or change the day to be analyzed. Note that, if you choose a different day, it must be a day for which the model has already been run. This flexibility is provided because the curve portion of the model may be run separately.

Weapon System Name is 0F111D0D1800

The latest ASM run was for day 30. You may select another day for which the ASM has already been run. Enter the day to be analyzed, or <CR> to analyze day 30. ==>

Example Response: <CR>

The model then asks for the target confidence level. The confidence level chosen here is used to pick a point on the curve and list total costs. Keep in mind that this is the confidence of achieving the selected DSO (number of grounded aircraft permitted) on the day of analysis based on the runtime parameters.

Enter the target confidence level. ==>

Example Response: .8

You then have the option of choosing a cost increment for the curve. The default is computed on the basis of the starting "sunk" costs – the costs associated with the pipeline floor and/or negotiated level options.

Enter a cost increment for the curve or
enter <CR> to let the program choose a value.
==>

Example Response: <CR>

Before displaying the curve, you may want to turn on your printer to get a hard copy at the same time. The model displays a message accordingly.

If a printer is connected, now is a good time to toggle it on by pressing the CTRL & PRTSC keys. It may be toggled off with the same CTRL command.

The curve that is generated usually exceeds one screen of data. Therefore, you have the option of pausing after each screen.

Would you like the printing of the curve to pause
after each screen of data Y/N? ==>

Example Response: Y

The curve then starts printing with the comment, weapon system name, day of analysis, and total sunk costs echoed first. Total sunk costs are either the cost of

pipeline purchases, negotiated costs, or components purchased during initial processing to get the mathematical algorithms initiated.

NOTE: SAMPLE DM4.4 DECK FOR F111 WRSK

Y

For the "F111" system, for day 30 of the surge.

Total Sunk Costs = 6061680

Confidence	Total Cost
0.00 %	6061680.
0.00 %	7061680.
0.00 %	8061680.
0.00 %	9061680.
.	.
74.33 %	48061680.
77.38 %	49061680.
80.18 %	50061680.
82.68 %	51061680.
.	.
99.99 %	93061680.
100.00 %	94061680.
100.00 %	95061680.
100.00 %	96061680.

ESTIMATED COST FOR PERFORMANCE

Pr(NMCS <= 5.0) = 0.80

The breakout of subtotal cost by item type is

ITEM TYPE	COST
LRUS with children and SRUS	38335236
LRUS with no children	11663739
NOP Items	0

Total Cost: 49998975

The estimated cost of performance indicates a breakout² of costs for this decision. It is, however, only an estimate. You will notice that there is no actual 0.8 (80.00 percent) in the table on the screen above. Therefore, the confidence level and its associated cost must be interpolated. Exact figures are obtained by running the "shopping list" programs. (See Chapter 4.) However, these confidence and cost

²Treatment of non-optimized (NOPed) items is currently under review. The breakout of the cost of NOPed items is intended for a future version of the ASM.

figures are close enough to perform comparative iterations to arrive at your goals before running the shopping list programs.

Next, you are given the opportunity to generate an actual graph of the table. To do this, you must have graphics capability on your system.

```
Would you like a graphic display of the Cost  
versus availability table. NOTE - Your machine  
must have graphics capability! Enter Y/N<CR>.  
==>
```

Example Response: Y

The following prompt allows you to direct the graph to your printer instead of your screen.

```
Press S (or <CR>) to display the graph on the screen,  
or P to print it on the printer.  
==>
```

Example Response: S

The curve shown in Figure 3-1 provides a clear picture of the relationship between incremental expenditures and confidence level for a particular spares kit. Press <CR> to continue.

The ASM prints a closing message. At this point, you can rerun just the curve (enter "CURVE") program to choose a different confidence-level cutoff or choose a different cost increment. Other parameter changes such as DSO or pipeline floor options would require the ASM to be rerun from the beginning. Then you could

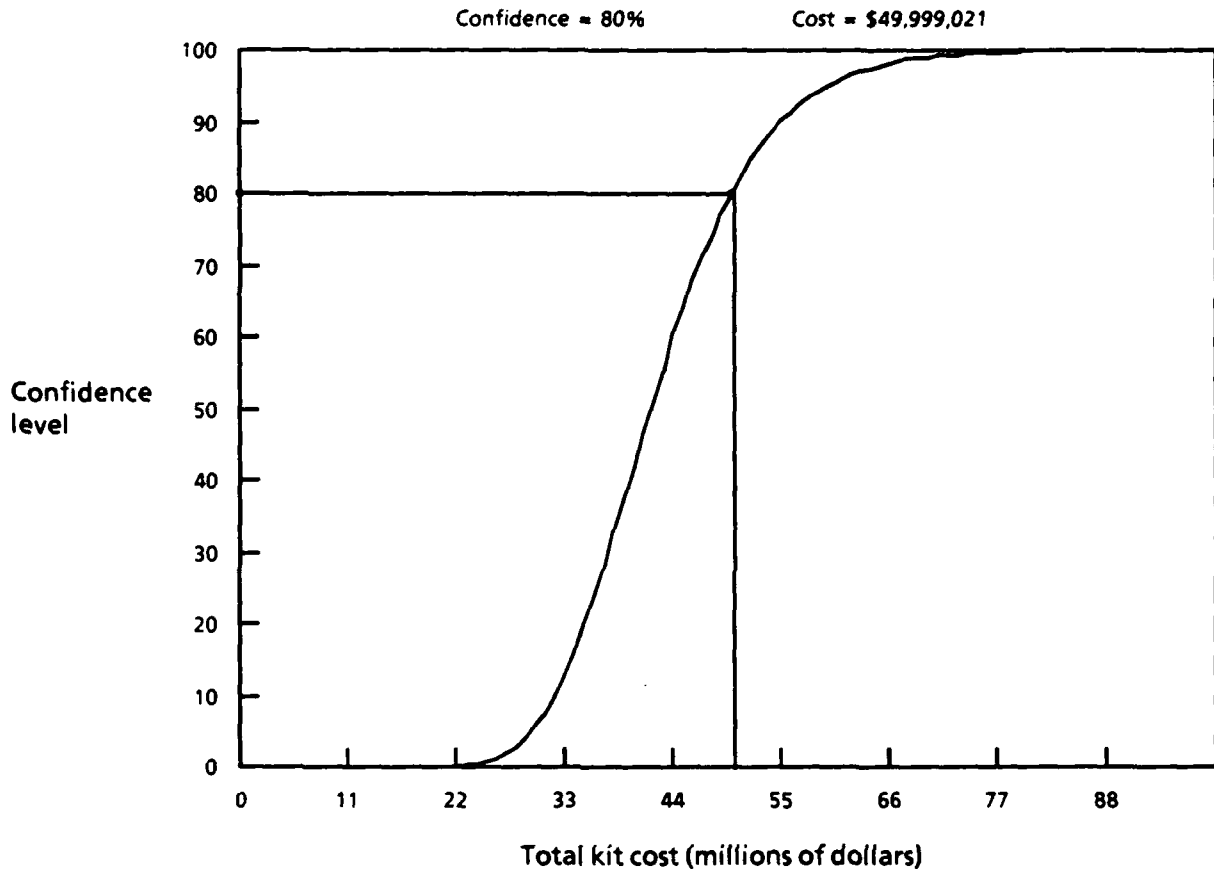


FIG. 3-1. COST VS. CONFIDENCE FOR THE F111 FOR DAY 30 (DSO = 5)

proceed to run the shopping list program (LISTSHOP, Chapter 4) or the priority list program (LISTPART, Chapter 5).

```

*****
**
** TO PRINT THE CURVE USING A DIFFERENT COST INCREMENT, OR TO SELECT **
**   A DIFFERENT PROBABILITY OF ACHIEVING THE DSO, ENTER "CURVE" **
**
** TO RUN THE ASM ON ANOTHER DAY, RE-RUN BY ENTERING "ASM" AGAIN. **
**
** TO GENERATE A SHOPPING LIST, ENTER "LISTSHOP DD", WHERE **
**   DD IS THE DAY **
**
** TO GENERATE A PRIORITY PARTS LIST, ENTER "LISTPART DD" **
**
*****

```

ASM OUTPUTS

The ASM creates many output files that are used by the curve program and the other modules of the system. Of these, the pipeline files may prove useful or interesting when evaluating a WRSK. All of the files are found in the output directory specified in the PARAMS file (the default is \ASMOUTPUT).

The model generates one pipeline file for LRUs and one for SRUs. The naming convention for these is OUTPIPE.xdd, where x=1 for LRUs, x=2 for SRUs, and dd=the day of analysis for a particular run. For example, OUTPIPE.130 is the LRU pipeline file for a day 30 analysis.

The file is sorted by national stock number (NSN) and column headings are included for easy reading. (See Figure 3-2.)

SAMPLE DYNA-METRIC 4.4 DECK FOR F111 WRSK								
DETAILED PIPELINE SEGMENT REPORT FOR DAY 30 OF SCENARIO								
NSN	CPIPE	DRPIPE	BRPIPE	AWP	OSPIPE	TOTAL	STOCK	EBOS
1270004053252BJ	0.00	0.00	0.95	0.00	0.00	0.95	0	0.95
1270004053253BJ	0.00	0.00	0.63	0.00	0.00	0.63	0	0.63
1270011139433BJ	0.00	0.00	4.00	0.00	0.00	4.00	0	4.00
1280004914282BJ	0.00	0.00	2.32	0.00	0.00	2.32	0	2.32

FIG. 3-2. OUTPIPE.xdd FILE

Following the NSN are the five pipeline columns: condemnations (CPIPE), depot repair (DRPIPE), base repair (BRPIPE), awaiting parts (AWP), and order and ship (OSPIPE). A total pipeline column is next, followed by any starting stock³ that was included, and finally the expected backorders (EBOs). The layout for both the LRU and SRU files is identical.

³Sometimes, when pipeline values are large, the model will "buy" some starting stock to properly initialize the marginal analysis computations. Any stock purchased for this reason, in addition to pipeline or negotiated level buys, will be included in the "STOCK" column of the OUTPIPE files.

CHAPTER 4

SHOPPING LISTS

LISTSHOP

After the ASM has generated a curve for the availability target you choose, the next logical step is to create a "shopping list" of components that meets that target. The LISTSHOP module accomplishes this task.

To execute LISTSHOP, enter "LISTSHOP dd," where dd is a day you have previously analyzed. The program then processes the output files from the ASM run. It echoes the target availability that was chosen for that day, the approximate cost that was interpolated during the ASM run, the total expenditure for LRUs, and the total expenditures for all components.

```
C:\ASM>LISTSHOP 30
```

```
C:\ASM>ECHO OFF
```

```
*****
**                                                                 **
**              NOW RUNNING THE SHOPPING LIST PROGRAM              **
**                                                                 **
*****

      SAMPLE DM 4.4 DECK FOR F111 WRSK
Availability target =      80.02%      Approximate cost   = 49999000.00

Total expenditure FOR LRUs ONLY      = 45372500.00

Total expenditure FOR ALL COMPONENTS = 50152220.00
Strike a key when ready . . .
*****
**                                                                 **
**              SHOPPING LIST PROGRAM FINISHED                      **
**                                                                 **
**  SHOPPING LISTS HAVE BEEN CREATED IN THE "OUTPUT" DIRECTORY.    **
**  AFTER CHANGING TO THE OUTPUT DIRECTORY YOU CAN DISPLAY SHOPPING **
**  LISTS FOR A GIVEN DAY (30) BY ENTERING:                         **
**                                                                 **
**      "TYPE SHOPLIST.130" - 1ST LEVEL INDENTURE COMPONENTS        **
**      "TYPE SHOPLIST.230" - 2ND LEVEL INDENTURE COMPONENTS.      **
**                                                                 **
**  YOU MAY EVALUATE THE EXACT CONFIDENCE LEVEL ACHIEVED WITH THESE **
**  ASSETS BY RUNNING "EVALSHOP 30". THIS WILL ALSO INDICATE THE   **
**  ENMCS AND THE PROBABILITY OF MEETING THE DSO.                  **
**                                                                 **
*****
C:\ASM>
```

The final screen during the processing indicates that the shopping lists have been created in the OUTPUT directory. The file names are SHOPLIST.xdd, where $x=1$ for LRUs, $x=2$ for SRUs, and dd =the day of analysis. These files are sorted by NSN and represent the computed stockage level for each item in the kit. (See Figure 4-1.) The "NUMBER BOUGHT" column includes all sunk buys such as pipeline (if selected) and negotiated requirements. Target and actual bought numbers will be the same if you had no starting stock.

```

C:\ASM\OUTPUT>TYPE SHOPLIST.130
      SAMPLE DM 4.4 DECK FOR F111 WRSK

FOR THE "F111DYNA      " SYSTEM, FOR THE 30th DAY

```

COMPONENT NAME	COST	TARGET	NUMBER BOUGHT	LEVEL	BUDGET CODE
1270004053252BJ	2550.00	1	1	1	2
1270004053253BJ	3136.00	0	0	1	2
1270011139433BJ	2550.00	3	3	1	2
1280004914282BJ	10618.00	4	4	1	2
1280011945412BJ	46580.00	7	7	1	2
1290010651234BJ	161419.00	5	5	1	1
1430002275734BJ	1051.00	0	0	1	2
1430002275736BJ	1480.00	0	0	1	2
1430002275740BJ	2002.00	0	0	1	2

FIG. 4-1. SHOPLIST.xdd FILE

In addition to the buy quantities, the SHOPLIST file contains the item cost, indenture level (1 for LRUs and 2 for SRUs), and budget code.¹

EVALSHOP

To make a more precise evaluation of the performance of the shopping list produced by LISTSHOP, run the EVALSHOP module. This program begins by adding the assets from the shopping list files to the asset position of the component data files from the ASM run.

¹The budget codes are currently set to 1 for SRUs and parent [remove, repair, and replace (RRR)] LRUs, 2 for remove and replace (RR) LRUs, and 3 is reserved for future versions to indicate that the item is NOPed.

```
C:\ASM>EVALSHOP 30
```

```
C:\ASM>ECHO OFF
```

```
*****  
**  
**   NOW ADDING THE 'LISTSHOP' SPARES TO THE ASSET POSITION   **  
**  
*****
```

```
THE COMMENT FROM THE ASM RUN IS  
      SAMPLE DM 4.4 DECK FOR F111 WRSK  
# LRUS PROCESSED =          305  
  
# OF SRUS PROCESSED =          296
```

The new component files are named EVALDATA.1 for LRUs and EVALDATA.2 for SRUs. The ASM is then executed using these new files. You do have the opportunity to change the runtime parameters, but for an evaluation run you normally would use the default values. The purpose of EVALSHOP is to determine the "exact" performance that the purchased assets will provide. When this evaluation run is complete, EVALSHOP will display the total cost, the exact confidence level, the expected number of grounded aircraft (ENMCS), and the total LRU EBOs for all components. Note that the latter two performance measures, ENMCS and EBOs, were not computed by any preceding module.

```
*****  
**  
**   EVALL RUN COMPLETE. GENERATING RESULT.   **  
**  
*****
```

```
      Evaluating day 30
```

```
      SAMPLE DM 4.4 DECK FOR F111 WRSK
```

```
      Total Cost =      50152220.
```

```
      Confidence =      80.36 %
```

```
      ENMCS      =      4.68
```

```
      Total EBO  =      202.33
```

```
Strike a key when ready . . .
```

This completes the normal processing cycle for determining exact availability levels and associated costs for a particular scenario. The next chapter discusses the LISTPART program, an auxiliary program that produces the priority parts list.

CHAPTER 5

LISTPART

The LISTPART module of the ASM produces a prioritized list of marginal buys in descending order of benefit per dollar. This list can be used to optimize spares procurement within a constrained budget.

LISTPART may be executed independently of the other shopping list modules. For example, LISTPART may be run immediately after the main ASM module. To execute, simply enter "LISTPART dd", where dd is the day of the ASM run. The program indicates the total sunk costs as computed by the model run, the number of LRUs (NSNs), the number of marginal records (actual number of component buy records generated), the day of analysis, and the kit identifier. The program then requests a three-character file name extension to be used for the output files.

```
*****
**
**          NOW RUNNING THE LIST PARTS PROGRAM          **
**
*****

SUNK COST = 6061680.00
# NSNS = 305 # MARGINAL RECORDS = 2401

DAY OF ANALYSIS AND/OR KITID INVALID OR NOT SUPPLIED
USING DAY 30
USING KITID =0F111D0D1800
ENTER A 3 CHARACTER EXTENSION TO BE USED FOR THE OUTPUT FILES
USE A UNIQUE NAME TO AVOID OVERWRITING AN EXISTING FILE ==>
```

Example Response: FLE

When processing is complete, a message is printed that indicates the name of the output file. Note that this file will be in the output directory specified in the PARAMS file.

```

*****
**                                     **
**                               FINISHED                               **
**                                     **
** THE PRIORITY PARTS LIST IS IN THE PARTLIST.FLE FILE **
** OF YOUR OUTPUT DIRECTORY. **
**                                     **
*****

```

The output file from LISTPART is a more detailed listing of the confidence/cost table produced by the ASM. The file displays a record of each marginal buy made during processing and its effect on cost and performance. (See Figure 5-1.) The total cost and the probability of meeting the DSO increase as one reads down the file. The last column shows the average number of aircraft grounded for lack of spares on the day of analysis, expressed as ENMCS aircraft.

This file provides the analyst with concrete data to defend budget requirements and also makes the effects of budget constraints immediately apparent. Comparison of PARTLIST files from different ASM runs is also useful.

One entry in the file that should be explained is the "SELL" notation that appears in the first column for some records. This occurs when it was optimal to buy some units of constituent SRUs of a particular LRU at one expenditure level; but, at a higher expenditure level, it becomes optimal to buy units of the LRU *instead* of the SRUs. This appears on the marginal buy list as a purchase that combines "selling" some SRUs with "buying" an LRU. This pattern may occur throughout the file.

FOR THE F111 KIT - FOR THE F111 AIRCRAFT
 STARTING COST = 6061680.00 STARTING PROBABILITY 0.00000
 STARTING ENMCS = 18.554

HOW MANY	NSN	COST	TOTAL COST	PROB	ENMCS
BUY 1	6220009250505	2837.00	6064517.00	0.00000	18.525
BUY 1	6220009250505	2837.00	6067354.00	0.00000	18.507
BUY 1	5841011900740	3227.00	6070581.00	0.00000	18.502
BUY 1	5821011659342	1509.00	6072090.00	0.00000	18.502
...					
BUY 1	1660007608698	15727.00	47381400.00	0.72206	5.025
BUY 1	1660008803660	1750.00	47383140.00	0.72211	5.025
SELL 1	5841011575015BJ AND				
SELL 1	5841011581306BJ AND				
SELL 1	5841011570209BJ AND				
SELL 1	5841011570208BJ AND				
SELL 1	5841011556415BJ AND				
SELL 1	5841011585221BJ AND				
SELL 1	5841011556421BJ AND				
SELL 1	5841011556419BJ AND				
SELL 1	5841011570199BJ AND				
SELL 1	5841011569699BJ AND				
SELL 1	5841011570210BJ AND				
SELL 1	5841011556411BJ AND				
SELL 1	5841011556414BJ AND				
SELL 1	5841011556409BJ AND				
SELL 1	5841011556410BJ AND				
BUY 1	5841011573940BJ	495687.50	47878830.00	0.73760	4.970
BUY 1	5865010226155EW	10214.00	47889050.00	0.73792	4.969
BUY 1	5865009251324EW AND				
BUY 1	5865002152664EW	1186.88	47890240.00	0.73796	4.968

FIG. 5-1. PARTLIST FILE

REFERENCES

- [1] Hillestad, R. J., *Dyna-METRIC: Dynamic Multi-Echelon Technique for Recoverable Item Control*, R-2785-AF, Santa Monica, Calif.: The RAND Corporation, Jul 1982.
- [2] Isaacson, Karen E., et al., *Dyna-METRIC Version 4: Modeling Worldwide Logistics Support of Aircraft Components*, R-3389-AF, Santa Monica, Calif.: The RAND Corporation, May 1988.
- [3] O'Malley, T. J., *The Aircraft Availability Model: Conceptual Framework and Mathematics*, Task AF201, Washington, D.C.: Logistics Management Institute, Jun 1983.
- [4] King, Randall M., *Assessing Aircraft Spares Support in a Dynamic Environment*, LMI Working Note AF401-3, Bethesda, Md.: Logistics Management Institute, Jul 1985.
- [5] Slay, F. Michael and Randall M. King, *Prototype Aircraft Sustainability Model*, LMI Report AF601R2, Bethesda, Md.: Logistics Management Institute, Mar 1987.
- [6] Slay, F. Michael, *VARI-METRIC: An Approach to Modeling Multi-Echelon Resupply When the Demand is Poisson with a Gamma Prior*, LMI Working Note AF301-3, Washington, D.C.: Logistics Management Institute, Jul 1980.

APPENDIX A

AIRCRAFT SUSTAINABILITY MODEL FILE FORMATS

LRU COMPONENT DATA - prefix.1

Each line replaceable unit (LRU) component in the War Readiness Spares Kit (WRSK) will have a corresponding series of seven records in this file. These are read as FORTRAN free-format records with fields separated by a blank space and column positioning is insignificant.

Record No. 1

NSN	=	National stock number of the component.
COST	=	Unit cost.
IQPA	=	Quantity installed per aircraft.
FAP	=	Future application percentage: the percentage of aircraft that will be configured with this NSN.
PLTT	=	Procurement leadtime in months.
ITASSE	=	The starting asset position for the NSN before any buys are made by the Aircraft Sustainability Model (ASM).
NHANSN	=	NSN of the next higher assembly (NHA); the next higher assembly for LRUs will be the weapon system, in this case F111.
IBUDCODE	=	A budget code integer from 1 to 9 that permits cost subtotals to be generated by budget code. Currently, a value of 1 denotes an LRU with shop replaceable units (SRUs) and 2 denotes an LRU without SRUs.
NEGLV	=	Negotiated level for this NSN. Sometimes, requirements levels are set without regard for optimization. If NEGFLAG [in the parameters (PARAMS) file] is set to true, the model will buy up from ITASSE to NEGLV sacrosanct.
MAINTCON	=	Specifies whether the LRU is remove and replace (RR) or remove, repair, and replace (RRR). This affects when (if ever) wartime LRU base repair begins.

ITEMTYPE = Equals LRU.

STAR = Reserved for future use. Set to "N" for now.

NOPFLAG = Applicable only to data drawn from the Air Force's WRSK/BLSS (Base Level Self-Sufficiency) and Authorization Computation System (D029). A value of "NOP" indicates that the item is non-optimized (NOPed). However, NOPed items are still a factor in constrained budget analysis. Processing of NOPed items is currently being developed.

NRTSDEC = Decision to ship this component to the next higher servicing facility is made before attempting repair (1) or after repair (0).

Record No. 2

IBRTP = Peacetime base repair time in days for this component.

IBRTW = Wartime base repair time in days for this component.

Record No. 3

IOSTP = Peacetime order and ship time in days for this component.

IOSTW = Wartime order and ship time in days for this component.

Record No. 4

IDRTP = Peacetime depot repair time in days for this component.

IDRTW = Wartime depot repair time in days for this component.

Record No. 5

TOIMDRP = Peacetime demand per flying hour for this component.

TOIMDRW = Wartime demand per flying hour for this component.

Record No. 6

BNRTSP = Base not reparable this station rate – peacetime percentage of demands that are either condemned or sent to the depot for repair (overhaul) for this component.

BNRTSW = Base not reparable this station rate – wartime percentage of demands that are either condemned or sent to the depot for repair (overhaul) for this component.

Record No. 7

CONPCTP = Peacetime condemnation percent for this component.

CONPCTW = Wartime condemnation percent for this component.

SRU COMPONENT DATA FILE - prefix.2

Each SRU component in the WRSK will have a corresponding series of ten records in this file. These are read as FORTRAN free-format records with fields separated by a blank space and column positioning is insignificant.

Record No. 1

NSN = National stock number of the component.

COST = Unit cost.

IQPA = Quantity installed per aircraft.

IQPANHA = Quantity of this component installed on its parent.

FAP = Future application percentage: the percentage of aircraft that will be configured with this NSN.

PLTT = Procurement leadtime in months.

ITASSE = The starting asset position for the NSN before any buys are made by the ASM.

NHANSN = NSN of the next higher assembly (NHA); the next higher assembly for LRUs will be the weapon system, in this case F111.

IBUDCODE = A budget code integer from 1 to 9 which permits cost subtotals to be generated by budget code. Currently, all SRUs have IBUDCODE set to 1.

NEGLV = Negotiated level for this NSN. Sometimes, levels are set outside of the mathematical model that instruct the model to buy without regard for optimization. If NEGFLAG (in the PARAMS file) is set to true, the model will buy up from ITASSE to NEGLV sacrosanct.

MAINTCON = Specifies whether the LRU is remove and replace (RR) or remove, repair, and replace (RRR). This affects when (if ever) wartime LRU base repair begins.

ITEMTYPE = Equals SRU.

STAR = Reserved for future use. Set to "N" for now.

NOPFLAG = Applicable only to data drawn from the Air Force's D029 system. A value of "NOP" indicates that the item is non-optimized (NOPed). SRUs should not be coded as NOPed items.

NRTSDEC = Decision to ship this component to the next higher servicing facility is made before attempting repair (1) or after repair (0).

Record No. 2

IBRTP = Peacetime base repair time in days for this component.

IBRTW = Wartime base repair time in days for this component.

Record No. 3

IOSTP = Peacetime order and ship time in days for this component.

IOSTW = Wartime order and ship time in days for this component.

Record No. 4

IDRTP = Peacetime depot repair time in days for this component.

IDRTW = Wartime depot repair time in days for this component.

Record No. 5

TOIMDRP = Peacetime demand per flying hour for this component.

TOIMDRW = Wartime demand per flying hour for this component.

Record No. 6

BNRTSP = Base not reparable this station rate — peacetime percentage of demands that are either condemned or sent to the depot for repair (overhaul) for this component.

BNRTSW = Base not reparable this station rate — wartime percentage of demands that are either condemned or sent to the depot for repair (overhaul) for this component.

Record No. 7

CONPCTP = Peacetime condemnation percent for this component.

CONPCTW = Wartime condemnation percent for this component.

Record No. 8

NHABRTP = Peacetime base repair time in days of parent component.

NHABRTW = Wartime base repair time in days of parent component.

Record No. 9

NHADRPP = Peacetime demand per flying hour of parent component.

NHADRPW = Wartime demand per flying hour of parent component.

Record No. 10

NHANRTSP = Not reparable this station percentage of parent component in peacetime.

NHANRTSW = Not reparable this station percentage of parent component in wartime.

PARAMETERS FILE - PARAMS

The PARAMS file contains all the system parameters for a particular ASM run such as the weapon system name, the flying program for the scenario, the day to be analyzed, the direct support objective (DSO), the first day that base repair of LRUs are permitted, and the type of computer on which the model run is being made (PC for personal computer, or HON for Honeywell).

These are read as FORTRAN free-format records. In this file, each field must be on a separate line.

ITODAY = The day to be analyzed. Must be between 0 and 99.

DATADIR = The drive/directory that contains the ASM input data. For example, C: \ASM\DATA\ or \ASM\F111DATA\. Note the trailing backslash (\) that is required.

OUTPDIR = The drive/directory that contains the ASM output. For example, \ASM\OUTPUT\F111\.

DEBUGER = Specifies the extent to which debug output should be printed. Must be FULL, SOME, NONE, or NSNS; defaults to NONE.

PIPEFLAG = Specifies whether the computed pipeline quantities will be written to the OUTPIPE file. Must be T or F; defaults to T.

TEST = For development work only. Must be set to F.

- NSNFILE** = If **DEBUGER** is set to **NSNS**, it specifies the file where a list of **NSNS** is stored. This file must be in the **DATADIR** directory and must contain one **NSN** per record. The **ASM** will then print debug output for each **NSN** in that list.
- NEGFLAG** = Specifies whether the model is to treat **NEGLV** as a sacrosanct level. Must be **T** or **F**. **T** indicates purchase of **NEGLV** quantity as a floor.
- EXPRESUP** = Specifies that resupply is exponential rather than deterministic. Must be **T** for exponential or **F** for deterministic.
- FAST** = For development work only. Must be set to **F**.
- BUYPEAK** = Specifies whether the peak pipelines for the whole scenario, as opposed to the pipelines on the day to be analyzed (**ITODAY**) are to be bought sacrosanct to the level specified by **PBUY** (see below). Must be **T** or **F**.
- COMPUTER** = Distinguishes version of **ASM**. Should be set to "PC".
- VMOPTION** = Specifies how the variance-to-mean ratio (**VMR**) computation is to be performed. May be 1, 2, 3, or 4 but anything greater than 1 (fixed **VMR**) is highly experimental.
- Q** = For **VMOPTION**=1, specifies the constant **VMR**. Must be at least 1.0.
- PBUYA** = Specifies the percentage of the pipeline to be bought sacrosanct; either peak or for **ITODAY**, see **BUYPEAK**. A value of 1.0 would specify buy the whole pipeline, 0.5 would buy half, 0.0 would buy none. **PBUYA** consists of two numbers: the first is the value for **LRUs**, the second for **SRUs**.
- WSNAME** = Weapon system name (e.g., **F111**, **F004**, etc.).
- NUNITS** = Number of units of the weapon system at each base (**PAA**).
- NBASES** = Number of bases.
- NFIRSTBR** = The first day base repair is allowed. Base component repair is suspended for days 1 through **NFIRSTBR**-1. **NFIRSTBR** is an array of three numbers: **NFIRSTBR**(1) is the first day that **RR LRUs** are repaired, **NFIRSTBR**(2) is the first day that **RRR LRUs** are repaired, **NFIRSTBR**(3) is the first day that **SRUs** are repaired.
- NFIRSTDR** = The first day depot repair is allowed. Depot component repair is suspended for days 1 through **NFIRSTDR**-1. **NFIRSTDR** is an array of three numbers: **NFIRSTDR**(1) is the first day that **RR**

LRUs are repaired, NFIRSTDR(2) is the first day that RRR LRUs are repaired, NFIRSTDR(3) is the first day that SRUs are repaired.

- NFIRSTOS = The first day that shipment from the depot becomes available.
- DSO = The number of not mission capable for supply (NMCS) aircraft allowed. The model optimizes the probability that the number NMCS is not greater than the DSO.
- FNAME = The name (without extension) of the files containing the LRU and SRU component data.
- NDAYS = The last day for which the component data will change. The component data is specified for day 0 through day NDAYS (in the COMPDATA file). The component data on days before day 0 are assumed identical to day 0. The component data on days after day NDAYSFH are assumed to be identical to day NDAYSFH. For now, NDAYS is set to 1 – i.e., resupply times, failure rates – are assumed to be constant for each day of the war.
- NDAYWARN = The number of days of warning before the start of the scenario (normally set to 0). Allows the resupply times to shift to the wartime values before the start of the scenario.
- COMMENT = Up to 80 characters of notes. This is a separate record in the file and may contain blanks.

SCENARIO FILE – prefix.SC

The scenario file contains specific items about the flying-hour program for an ASM run. These are read as FORTRAN free-format records. In this file, each field must be on a separate line.

- NDAYSFH = The last day for which the flying program will change. The flying program is specified for day 0 through day NDAYSFH. (See the next field, FHP.) The flying programs on days before day 0 are assumed identical to day 0. The flying programs on days after day NDAYSFH are assumed to be identical to day NDAYSFH.
- FHP = The array of the flying-hour program in hours per day, for days 0 through NDAYSFH.

APPENDIX B

COMPARISON OF THE AIRCRAFT SUSTAINABILITY MODEL 1.5 AND DYNA-METRIC 4.4

BACKGROUND

The Aircraft Sustainability Model (ASM) was originally developed as a research tool to be used by the Air Staff (specifically, Headquarters, U.S. Air Force, Logistics Plans and Programs) in formulating and defending budget requirements for War Reserve Materiel (WRM). WRM consists of two parts. First is War Reserve Spares Kits/Base Level Self-Sufficiency (WRSK/BLSS) stocks used to support deploying or in-place units for the first 30 days of a conflict scenario. Second is Other War Reserve Materiel (OWRM) stocks used to sustain capability past day 30 until normal resupply and production have been re-established. The ASM was originally intended to provide new capabilities for analyzing the OWRM portion of WRM.

At about the same time that the ASM was being developed, the Weapon System Management Information System (WSMIS) was undergoing replacement of the WRSK/BLSS Computation System (D029) with the Dyna-METRIC¹ (DM) Version 4.4 model. DM 4.4 was developed by The RAND Corporation as a way to extend the steady-state marginal analysis techniques used in the computation of peacetime requirements to dynamic wartime scenarios. DM had been used for a number of years in the Air Force as an assessment tool. Incorporating DM 4.4 into the Requirements Execution Availability Logistics Model (REALM) of WSMIS would bring compatibility between requirements computation and Air Force assessments. In addition, DM 4.4 was able to distinguish between the value of line replaceable units (LRUs) installed directly on an aircraft and shop replaceable units (SRUs) used to repair LRUs. This had been a key weakness in the D029 computation.

Two deficiencies in DM 4.4 led to the implementation of the ASM. First, while DM 4.4 can assess appropriately the benefits of LRU and SRU stocks, it *does not*

¹Dyna-METRIC = Dynamic Multi-Echelon Technique for Recoverable Item Control.

tradeoff LRUs against SRUs. Thus, it can only approximate the least cost mix of spares to meet a particular level of performance. The ASM, on the other hand, performs this tradeoff explicitly. Second, an objective in REALM was to use DM 4.4 to determine requirements as well as execute constrained budgets — i.e., to determine the best mix of spares for any level of available funding. DM does not readily meet this requirement. The ASM, because it solves the requirements problem by producing an entire curve of cost against performance, is an ideal tool for dealing with constrained funding. Because the ASM handles these problems and is also computationally efficient, the WSMIS Program Office investigated the possibility of incorporating the ASM within the DM framework. This approach proved conceivable since the ASM and DM are fundamentally compatible in two crucial respects:

- *Pipeline Computations.* Both models compute the same expected number in resupply (base repair, order-and-ship, etc.). The only deviation here regards the awaiting parts (AWP) segment of the LRU pipeline. DM and the ASM have the same mathematical theory, but DM approximates the calculation whereas the ASM is exact. The error in the approximation has been shown to be significant and the Air Force Logistics Command (AFLC) is taking steps to correct the problem in DM 4.4.
- *Objective Function.* Both models strive to find the least cost mix of spares with respect to a chosen direct support objective (DSO) and confidence level. Each model buys spares in accordance with the benefit per dollar associated with the confidence level, expressed as a probability, of having the DSO or fewer aircraft down. In other words, the goal is to maximize

$$\text{Pr}(\text{NMCS} \leq \text{DSO})$$

where, NMCS is the number of not mission capable for supply aircraft on the day of interest.

To further extend the compatibility, LMI enhanced the ASM, including building the CONVERTER program for passing DM 4.4 input data to the ASM. The integrated ASM/DM software, known as Modified Dyna-METRIC, has been approved for installation into REALM.

The remainder of this appendix further compares and contrasts the two models.

WRSK/BLSS COMPUTATIONS

Since the purpose of installing ASM into REALM is to perform the WRSK/BLSS computations, every effort has been made to ensure consistency between the

ASM and DM in performing these standard requirements computations. This application includes one echelon (the fighting base) and two levels of indenture – LRUs and SRUs. The Air Force policy is to model all components as having Poisson demands and to assume repair times have an exponential distribution. Maximum cannibalization of LRUs and SRUs is assumed. In addition to computing the optimal mix of LRUs and SRUs, the ASM has two technical advantages in computing WRSK/BLSS. It is capable of implementing the Air Force DSO and minimum pipeline policies with greater accuracy:

- *Fractional DSO Targets.* Air Force policy indicates that the DSO should be 25 percent of the available aircraft. For an 18-aircraft squadron, for example, the ASM can process a DSO objective of 4.5 (25 percent of 18). DM processes integer values only and will round this DSO to 5.
- *Pipeline Floor Computations.* Air Force policy indicates buying the peak (maximum over the 30-day scenario) pipeline as a minimum. The ASM computes the pipeline as an expected value in accordance with Air Force policy and explicitly finds the peak. DM, on the other hand, uses a ready-rate formulation of pipeline and includes the AWP time for LRUs in the pipeline. It cannot directly compute the peak. Thus, the ASM is capable of implementing the current Air Force minimum floor policy with greater accuracy.

Again, the fundamental compatibility should be emphasized. Given a DSO and confidence-level target, the corresponding ASM buy quantities will assess, using either the ASM or DM, to identical confidence levels and aircraft availability.

MULTI-ECHELON COMPUTATIONS

While the standard WRSK/BLSS computations use only one echelon of supply, excursions are sometimes made that include a centralized intermediate repair facility (cirf) and/or a depot. Even though the ASM supports only two full echelons (DM has three), the ASM does tradeoff the value of spares by stockage location while DM does not. Thus, the advantage that the ASM has in dealing with multiple levels of indenture applies also to multi-echelon situations.

TREATMENT OF UNCERTAINTY

DM supports variance-to-mean ratios (VMRs) that can be either 1 (Poisson), greater than 1 (negative binomial), or less than 1 (binomial). The ASM uses either

Poisson or negative binomial for the distributions, but with a wider range of options, including the VARI-METRIC technique developed by Slay.²

DYNA-METRIC ASSESSMENT CAPABILITIES

Because of its longstanding use for assessments, DM has a number of assessment capabilities not available in the ASM. These are all capabilities that are not used in the current WRSK/BLSS requirements problem. These include

- *Nonuniform Bases.* The ASM Version 1.5 requires all bases to be identical with respect to activity levels and resupply capability.
- *Constrained Repair.* The ASM assumes unlimited repair capacity.
- *Partial Cannibalization.* DM supports no cannibalization, full cannibalization, and a component-by-component cannibalization indicator. The ASM currently supports only maximum cannibalization, although a more general capability will be included in the next ASM release.
- *Multiple Days on Analysis.* The ASM now processes each day separately, although the computational efficiency and processing speed of the ASM makes multiple executions for each day practical.

Development of the ASM continues in response to Air Force requirements. Improvements and enhancements are made to meet the needs of WSMIS/REALM and Air Force policy as well as to provide improved accuracy and efficiency. Constant updating will ensure that the ASM remains an integral part of the Air Force WRM system.

²F. Michael Slay, *VARI-METRIC: An Approach to Modeling Multi-Echelon Resupply When the Demand is Poisson with a Gamma Prior*, LMI Working Note AF301-3 (Washington, D.C.: Logistics Management Institute, Jul 1980).

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE

A207015

REPORT DOCUMENTATION PAGE

1a. REPORT SECURITY CLASSIFICATION Unclassified			1b. RESTRICTIVE MARKINGS		
2a. SECURITY CLASSIFICATION AUTHORITY			3. DISTRIBUTION / AVAILABILITY OF REPORT "A" Approved for public release; distribution unlimited.		
2b. DECLASSIFICATION / DOWNGRADING SCHEDULE					
4. PERFORMING ORGANIZATION REPORT NUMBER(S) LMI-AF801R2			5. MONITORING ORGANIZATION REPORT NUMBER(S)		
6a. NAME OF PERFORMING ORGANIZATION Logistics Management Institute	6b. OFFICE SYMBOL (if applicable)	7a. NAME OF MONITORING ORGANIZATION			
6c. ADDRESS (City, State, and ZIP Code) 6400 Goldsboro Road Bethesda, Maryland 20817-5886			7b. ADDRESS (City, State, and ZIP Code)		
8a. NAME OF FUNDING / SPONSORING ORGANIZATION Headquarters, U.S. Air Force	8b. OFFICE SYMBOL (if applicable) LEXX	9. PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER MDA903-85-C-0139			
8c. ADDRESS (City, State, and ZIP Code) The Pentagon, Room 4B283 Washington, D.C. 20330			10. SOURCE OF FUNDING NUMBERS		
			PROGRAM ELEMENT NO.	PROJECT NO.	TASK NO.
			WORK UNIT ACCESSION NO.		
11. TITLE (Include Security Classification) Aircraft Sustainability Model Version 1.5: Users Manual					
12. PERSONAL AUTHOR(S) Frank L. Eichorn					
13a. TYPE OF REPORT Permanent	13b. TIME COVERED FROM _____ TO _____	14. DATE OF REPORT (Year, Month, Day) March 1989		15. PAGE COUNT 52	
16. SUPPLEMENTARY NOTATION					
17. COSATI CODES			18. SUBJECT TERMS (Continue on reverse if necessary and identify by block number)		
FIELD	GROUP	SUB-GROUP	Aircraft availability; inventory modeling; inventory systems; resources to readiness; sparing-to-availability; multi-indenture; multi-echelon; War Reserve Materiel		
19. ABSTRACT (Continue on reverse if necessary and identify by block number)					
<p>The Aircraft Sustainability Model (ASM) is an inventory spares model developed for the Air Force that relates investment in War Reserve Material (WRM) to measures of aircraft availability. The ASM is a computationally efficient model that produces an entire curve of the cost/availability relationship. The ASM is being used by the Air Force both to compute the WRM budget and to determine the best mix of spares to be purchased with constrained funding.</p> <p>This manual documents the installation and execution instructions of the PC-version of the ASM software, Version 1.5. Included are descriptions of the input requirements and illustrations of model applications.</p>					
20. DISTRIBUTION / AVAILABILITY OF ABSTRACT <input checked="" type="checkbox"/> UNCLASSIFIED/UNLIMITED <input type="checkbox"/> SAME AS RPT. <input type="checkbox"/> DTIC USERS			21. ABSTRACT SECURITY CLASSIFICATION		
22a. NAME OF RESPONSIBLE INDIVIDUAL			22b. TELEPHONE (Include Area Code)		22c. OFFICE SYMBOL